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(54) Refrigerator with a frozen food compartment.

(57) A refrigerator with a frozen food compartment wherein cooled air which is produced by an evaporator (18) is forcibly carried to a refrigerating compartment (3) and other compartments (2, 5) by a fan (20); characterized in that it comprises:

a low temperature compartment (5) which is arranged in the refrigerating compartment (3), and which has a front portion opened;

a chilled food case (7) which is housed in the low temperature compartment (5) to be slidable forward and backward therein, and which has a front portion and an upper portion opened;

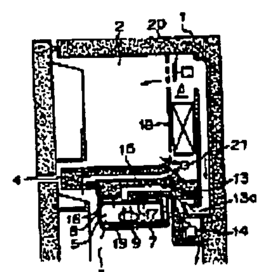
a common cover (8) which can close and disclose the front portions of the low temperature compartment (5) and the chilled food case (7);

a cooling top plate (16) for covering the upper opened portion of the chilled food case (7);

a cooled air path (17) which is formed between the top plate (16) and the low temperature compartment (5); and

a supply passage (13) which directs a part of the cooled air produced by the evaporator (18) to the cooled air path (17).

FIGURE 1



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The present invention relates to a chilled food case in a low temperature compartment, which is arranged in a refrigerating compartment.

Referring to Figures 29 and 30, there is shown a conventional refrigerator with a frozen food compartment which has been disclosed in Japanese Unexamined Utility Model Publication No. 55969/1985, as a perspective front view in Figure 29, and as a cross sectional view in Figure 30. In these Figures, reference numeral 1 designates the refrigerator as a whole. Reference numeral 2 designates a frozen food compartment. Reference numeral 3 designates a refrigerating compartment which is separated and isolated from the frozen food compartment 2 by a partition wall 4. Reference numeral 5 designates a low temperature compartment which is arranged at a top portion in the refrigerating compartment 3. Reference numeral 6 designates a salad drawer. Reference numeral 7 designates a chilled food case which is housed in the low temperature compartment 5 to be detachable from it. Reference numeral 8 designates a cover which is arranged at the front end of the chilled food case 7. Reference numeral 9 designates a low temperature housing which forms the low temperature compartment 5 and has an upper portion opened. Reference numeral 10 designates a lower partition wall which forms the bottom of the low temperature housing. Reference numeral 11 designates a cooled air pass which is arranged between the lower partition wall 10 and the undersurface of the chilled food case 7. Reference numeral 12 designates communication ports which communicate with the cooled air pass 11 to supply cooled air into the refrigerating compartment 3. Reference numeral 13 designates a supply passage which extents from an evaporator, and which controls the amount of the cooled air into the refrigerating compartment 3 by a damper thermostat 14. The damper thermostat automatically opens and closes a cooled air outlet 13a of the supply passage. Reference numeral 15 designates a shunt supply passage which directs part of the cooled air controlled at the damper thermostat 14 to the low temperature compartment 5, and which communicate with the cooled air pass 11.

The operation of the conventional refrigerator will be explained.

The cooled air which has been produced by the evaporator (not shown) is carried by a fan (not shown). A part of the cooled air passes through the supply passage 13 to the refrigerating compartment 3. The damper thermostat 14 which automatically opens and closes the cooled air outlet 13a depending on a temperature in the refrigerating compartment controls the amount of the cooled air to cool the inside of the refrigerating compartment 3 to a predetermined temperature (3°C). Another part of the cooled air passes through the cooled air pass 11 to cool the low temperature compartment 5, thereby cooling the inside of the low temperature compartment 5 to a predetermined temperature (0°C). Then that part of the cooled air passes through the communicating port 12, and enters the refrigerating compartment.

Since the conventional refrigerator cools the low temperature compartment in that manner, a great amount of the cooled air is forced to pass through an inner bottom portion of the low temperature compartment, and then the cooled air is discharged into an inner top portion of the refrigerating compartment. This creates problems in that the food which is stored in the low temperature compartment is frozen, and that high humidity cannot be kept because the low temperature compartment is not closed.

It is an object of the present invention to eliminate the problems mentioned above, and to provide a refrigerator with a frozen food compartment capable of preventing a chilled food case in a low temperature housing arranged in a refrigerating compartment from being frozen, and of keeping the inside of the chilled food case at high humidity to prevent stored food from being dried.

According to a first aspect of the present invention, there is provided a refrigerator with a frozen food compartment wherein cooled air which is produced by an evaporator is forcibly carried to a refrigerating compartment and other compartments by a fan; comprising a low temperature compartment which is arranged in the refrigerating compartment, and which has a front portion opened; a chilled food case which is housed in the low temperature compartment to be slidable forward and backward therein, and which has a front portion and an upper portion opened; a common cover which can close and disclose the front portions of the low temperature compartment and the chilled food case; a cooling top plate for covering the upper opened portion of the chilled food case; a cooled air path which is formed between the top plate and the low temperature compartment; and a supply passage which directs a part of the cooled air produced by the evaporator to the cooled air path.

In a second aspect of the present invention, the refrigerator including the first aspect further comprises a cooled air passage which communicates with the cooled air path, which is formed on an outer peripheral surface of the chilled food case, and which opens on the refrigerating compartment.

According to the first and second aspects, the low temperature compartment can be prevented from being frozen and also be closed to keep the inside of the chilled food case at high humidity.

In a third aspect of the present invention, the

refrigerator including the first aspect further comprises a cooled air return passage which returns the cooled air to the evaporator.

According to the third aspect, the cooled air which has flowed along the cooling top plate is returned to an evaporator chamber without being discharged into the refrigerating compartment, thereby allowing the inside of the chilled food case to have a desired temperature independently.

In a fourth aspect of the present invention, the refrigerator including the first aspect further comprises a fixing frame for the chilled food case, including an upper frame and a rear projecting frame; the upper frame covering the upper opened portion of the chilled food case and having the top plate put thereon; the rear projecting frame formed with the upper frame through a hinge portion in one-piece, forming a part of the cooled air passage, and having a rear end surface abutted against a rear inner wall of the low temperature compartment to be fixed.

According to the fourth aspect, locating the cooling top plate and the chilled food case can be accurately done.

In a fifth aspect of the present invention, the refrigerator including the first aspect is characterized in that the cooling top plate is arranged above the chilled food case, and is engaged with the low temperature compartment through a surrounding frame so as to be detachable downward, the surround frame being arranged around the cooling top plate.

According to the fifth aspect, the cooling top plate can be removed for cleaning without detaching the cover and the chilled food case.

In a six aspect of the present invention, the refrigerator including the first aspect is characterized in that the cooling top plate is made of a porous material.

According to the six aspect, excessive moisture in the low temperature compartment can be kept in the cooling top plate of the porous material.

In the seventh aspect of the present invention, the refrigerator including the six aspect is characterized in that the cooling cooling top plate comprises a hydrophilic porous material having a humidity adjusting function at the side of the cooled air path, and a hydrophilic porous material having a moisture absorption and moisture retention function at the side of the chilled food case.

According to the seventh aspect, the inside of the chilled food case can be kept at high humidity to restrain stored food from being dried, thereby obtaining high quality of preservation.

In an eighth aspect of the present invention, the refrigerator including the six aspect is characterized in that the cooling top plate comprises a hydrophilic porous material having a small porosity at the side of the cooled air path, and a hydrophilic porous material having a greater porosity at the side of the chilled food case.

According to the eighth aspect, when the inside of the chilled food case has low humidity, the part of the top plate which has a smaller porosity carries out such control that the absorbed moisture is prevented from being discharged to the cooled air path to an excessive extent, thereby obtaining high quality of preservation.

In a ninth aspect of the present invention, the refrigerator including the first aspect is characterized in that the cooling top plate contains a deodorizing catalyst and an antibacterial agent.

According to the ninth aspect, the deodorizing catalyst and the antibacterial agent which are contained in the cooling top plate work to prevent the chilled food case from having a fungus or an odor in it.

In a tenth aspect of the present invention, the refrigerator including the first aspect is characterized in that the cooled air path above the cooling top plate includes a heating element.

According to the tenth aspect, even if the cooling top plate is iced, the ice can be melted by the heating element which is arranged in the cooled air path above the cooling top plate.

In the eleventh aspect of the present invention, the refrigerator including the tenth aspect further comprises control means which carries out such control that the supply passage is shut while energizing the heating element at the time of defrosting the cooling top plate.

According to the eleventh aspect, when the chilled food case cooling top plate is defrosted, the supply passage can be shut to shorten a defrosting time period.

In a twelfth aspect of the present invention, the refrigerator including the eleventh aspect is characterized in that the heating element is provided with a temperature sensor, and has control means which carries out such control that the temperature of the heating element is kept at constant during energization.

According to the twelfth aspect, unnecessary heating of the top plate by the heating element can be avoided to obtain high quality of preservation.

In the thirteenth aspect of the present invention, the refrigerator including the tenth aspect further comprises a heating element for defrosting the cooling top plate and controlling the temperature in the chilled food case, and means for adjusting the heat generation from the heating element.

According to the thirteenth aspect, defrosting the top plate and maintaining the inside of the chilled food case at a certain temperature can be done by use of a single heating element.

In a fourteenth aspect of the present invention,

the refrigerator including the thirteenth aspect is characterized in that the heat generation adjusting means adjusts the heat generation, depending on the time period in which a compressor is being driven.

According to the fourteenth aspect, defrosting the top plate is carried out when the time period in which the compressor has been driven has passed a predetermined time period.

In drawings:

Figure 1 is a vertical cross sectional and partial diagrammatic view of a first embodiment of the refrigerator according to the present invention;

Figure 2 is an enlarged cross sectional view of the essential parts of the refrigerator according to the first embodiment;

Figure 3 is a graph showing the state of a decrease in moisture of stored food in accordance with the first embodiment;

Figure 4 is an enlarged cross sectional and partial diagrammatic view of the refrigerator according to a second embodiment;

Figure 5 is an enlarged cross sectional view of the essential parts of the refrigerator according to a third embodiment;

Figure 6 is an enlarged perspective view of the essential parts of the refrigerator according to the third embodiment;

Figure 7 is a front view of the essential parts of the refrigerator according to a fourth embodiment;

Figure 8 is a cross sectional side view of the essential parts of the refrigerator according to the fourth embodiment;

Figure 9 is a perspective view of the cooling top plate according to a fifth embodiment;

Figure 10 is a perspective view of the cooling top plate according to a sixth embodiment;

Figure 11 is a vertical cross sectional view of the essential parts of the refrigerator according to a seventh embodiment;

Figure 12 is an enlarged cross sectional view of the refrigerator according to the seventh embodiment;

Figure 13 is a schematic circuit diagram for the heating element of the refrigerator according to the seventh embodiment;

Figure 14 is another schematic circuit diagram for the heating element of the refrigerator according to the seventh embodiment;

Figure 15 is another schematic circuit diagram for the heating element of the refrigerator according to the seventh embodiment;

Figure 16 is a schematic circuit diagram for the heating element of the refrigerator according to an eighth embodiment;

Figure 17 is a graph showing the relationship between deodorizing performance and the heating element in the eighth embodiment;

Figure 18 is a vertical cross sectional view showing the essential parts of the refrigerator according to a ninth embodiment;

Figure 19 is a timing chart of the refrigerator according to the ninth embodiment;

Figure 20 is a flowchart for the refrigerator according to the ninth embodiment;

Figure 21 is a vertical cross sectional view showing the essential parts of the refrigerator according to a tenth embodiment;

Figure 22 is a timing chart for the refrigerator according to the tenth embodiment;

Figure 23 is a flowchart for the refrigerator according to the tenth embodiment;

Figure 24 is a vertical cross sectional view showing the essential parts of the refrigerator according to an eleventh embodiment;

Figure 25 is a control block diagram for the refrigerator according to the eleventh embodiment;

Figure 26 is a flowchart for the refrigerator according to the eleventh embodiment;

Figure 27 is a graph showing the heating element terminal voltage of the refrigerator according to the eleventh embodiment;

Figure 28 is a table showing the heating element energizing rate of the refrigerator according to the eleventh embodiment;

Figure 29 is a perspective view of a conventional refrigerator with a frozen food compartment; and

Figure 30 is an enlarged vertical cross sectional view showing the essential parts of the conventional refrigerator.

Now, the present invention will be described in detail with reference to preferred embodiments illustrated in the accompanying drawings.

EMBODIMENT 1:

A first embodiment of the present invention will be explained. In Figure 1, parts similar to the conventional refrigerator are indicated by the same reference numerals as the conventional refrigerator shown in Figures 29 and 30. Explanation of these parts will be omitted for the sake of simplicity. In Figure 1, reference numeral 7 designates a chilled food case which can be housed in a closed low temperature compartment 5, which can be slidable forward and backward, and which has a front portion and an upper portion opened, the closed low temperature compartment 5 being arranged just below a partition wall 4. Reference numeral 9 designates a low temperature housing which forms the closed low temperature compartment 5 in it, and which has an upper portion opened. Reference numeral 8 designates a common cover which

opens and closes a front portion of the low temperature housing and the front portion of the chilled food case 7. Reference numeral 16 designates a cooling top plate which covers the upper portion of the chilled food case 7, and which can be constituted by a porous material to hold moisture evaporated from stored food. Reference numeral 17 designates a cooled air path for the chilled food case 7, which is arranged in the closed low temperature compartment 5 so as to be located between the cooling top plate 16 and the undersurface of the partition wall 4. Cooled air which has been produced by an evaporator 18 is carried through a supply passage 13 toward a refrigerating compartment 3. A part of the cooled air, the amount of which is controlled by a damper thermostat 14 arranged in a cooled air outlet 13a of the supply passage 13, is directed through a shunt supply passage 15, and enters the cooled air path 17. That part of the cooled air flows along the cooling top plate 16 of the chilled food case 7. Then, as shown in Figure 2, that part of the cooled air flows through a cooled air passage 19 which is formed along outer side surfaces, an outer rear surface and an outer bottom surface of the chilled food case 7 and is discharged into the refrigerating compartment 3. Reference numeral 20 designates a fan which is arranged at an upper portion in an evaporator chamber A to forcibly circulate cooled air. Reference numeral 21 designates an evaporator defrosting heating element which is arranged just below the evaporator 18.

In operation, the cooled air which is produced by the evaporator 18 is fed by the fan 20 to be blown off into a frozen food compartment 2, thereby cooling it. A part of the cooled air is directed to the cooled air outlet 13a through the supply passage 13 toward the refrigerating compartment 3. That part of the refrigerant, the amount of which is controlled by the damper thermostat 14 in the cooled air outlet 13a, cools the inside of the refrigerating compartment 3 to a predetermined temperature (3°C).

Another part of the cooled air is directed through the shunt supply passage 15, and flows along the top surface of the cooling top plate 16 made from the porous material. Then that part of the cooled air flows along the outer surfaces of the chilled food case 7, and is discharged into the refrigerating compartment 3 through the cooled air passage 19.

The arrangement wherein the surface of the cooling top plate which the supplied cooled air is first given to has the lowest temperature among the temperatures in the chilled food case 7 prevents the temperatures of the inner bottom surface with stored food put thereon and the inner peripheral surfaces of the chilled food case 7 from lowering to excessive levels, thereby avoiding the state wherein the food stored in the chilled food case 7 is frozen. The arrangement wherein the front end opening of the closed low temperature compartment 5 and that of the chilled food case 7 in it can be closed by the common cover 8 to obtain a closed structure allows the inside of the chilled food case 7 to be kept at high humidity due to evaporation of moisture from the food to a slight extent. As shown in Figure 3, evaporation of moisture from the stored food can be restrained to keep freshness of the food.

In addition, because the cooling top plate 16 which is cooled to the lowest temperature among the temperatures in the chilled food case is made of the porous material capable of holding moisture, the cooling top plate can hold in itself the moisture which has evaporated in the chilled food case, and no vapor condensation is formed on other parts.

EMBODIMENT 2:

Referring now to Figure 4, there is shown a second embodiment. In Figure 4 which corresponds to Figure 1, parts similar to those of the conventional refrigerator of Figures 29 and 30 are indicated by the same reference numerals. Explanation of those parts will be omitted for the sake of simplicity.

The second embodiment is characterized in that a cooled air return passage 37 is formed in the partition wall 4 to direct the cooled air from the cooled air path 17 to the evaporator chamber A. In the second embodiment, a part of the cooled air which is directed from the evaporator 18 toward the refrigerating compartment 3 passes through the shunt supply passage 15, the amount of that part of the cooled air being controlled by the damper thermostat 14 which is arranged in the cooled air outlet 13a. Then that part of the air enters the cooled air path 17, flows along the top plate 16 of the chilled food case 7, and goes back directly into the evaporator chamber A through the cooled air return passage 37, thereby cooling the chilled food case 7 from the top surface independently of the refrigerating compartment.

The front openings of the low temperature compartment 5 and the chilled food case 7 are closed by the cover 8, and the top portion of the chilled food case is closed by the top plate 16. This arrangement prevents the cooled air from directly entering the chilled food case 7 while passing through the cooled air path 17, and keep high humidity in the chilled food case 7.

In accordance with the refrigerator of the second embodiment, the cooled air which has flowed along the chilled food case top plate in the low temperature compartment is returned directly to

the evaporator chamber through the cooled air return passage without being discharged into the refrigerating compartment. This arrangement offers advantage in that the chilled food case in the low temperature compartment can be independently cooled to a desired temperature without adverse effect to the temperature in the refrigerating compartment.

EMBODIMENT 3:

Referring now to Figures 5 and 6, there is shown a third embodiment wherein locating the chilled food case 7 to be housed in the closed low temperature compartment 5, and the top plate 16 can be free from variations. In Figure 5, parts similar or corresponding to the parts shown in Figure 2 are indicated by the same reference numerals. Explanation of those parts will be omitted for the sake of simplicity. In Figures 5 and 6, reference numeral 30 designates an upper frame which has the top plate 16 for the chilled food case 7 put thereon, and which forms between the top plate 16 and the undersurface of the partition wall 4 the cooled air path 17 which communicates with the shunt supply passage 15. A rear rib 32 which extends downward from the upper frame 30 through a hinge portion 31 as shown is fixed to the outer surface of the rear wall of the chilled food case 7 so that the rear rib 32 overlaps with the outer surface of the rear wall up to a predetermined height. Reference numeral 33 designates a rear projecting frame which forms between the rear rib 32 and itself cooled air outlets 34 in communication with the cooled air path 17, which has a rear end surface abutted against the inner surface of the rear wall of the low temperature housing 9, and which is constructed with the rear rib 32 in one-piece.

The arrangement of the third embodiment is characterized in that the cooled air passage 19 is formed around the chilled food case 7 and along the top plate 16 in the optimum manner under the state wherein the upper frame 30 and the rear projecting frame 33 are mounted in the low temperature housing 9, and the top plate 16 is put on the upper frame 30.

EMBODIMENT 4

Referring now to Figures 7 and 8, there is shown a fourth embodiment wherein mounting the chilled food case top plate 16 into the closed low temperature compartment 5 and removing the top plate 16 from the closed low temperature compartment 5 are facilitated. In Figures 7 and 8, parts similar or corresponding to those shown in Figure 5 are indicated by the same reference numerals. Explanation of these parts will be omitted for the sake of simplicity. In the fourth embodiment, the top plate 16 for the chilled food case 7 which is housed in the low temperature compartment 5 and which has the cooled air supplied from the evaporator 18 directed through the cooled air path 17 on it is formed to be smaller than the size of an upper opening of the chilled food case 7. The top plate 16 is engaged with an upper opening of the low temperature housing 9 through a surrounding frame 35 in a detachable manner to form between the chilled food case 7 and the low temperature housing 9 the cooled air passage 19 to the refrigerating compartment 3 for the cooled air which has passed through the cooled air path 17; the surrounding frame 35 being fitted to the inner peripheral end of the opening of the low temperature housing. The top plate 16 is held down from upward by ribs 36 to prevent inadvertent removal, the ribs 36 being arranged on the undersurface of the partition wall 4 to be project therefrom. The top plate 16 which is used in the third and fourth embodiments does not necessarily need the inclusion of the deodorizing catalyst and the antibacterial agent.

The arrangement of the fourth embodiment wherein the cooling top plate is arranged above the chilled food case and is engaged with the wall of the low temperature housing through the surround frame fitted to the inner peripheral end of the opening of the low temperature housing so that the top plate can be removed downward allows the top plate to be removed without detaching the cover or the chilled food case.

EMBODIMENT 5:

A fifth embodiment of the present invention will be described referring to Figure 9. In the fifth embodiment, the cooling top plate 16 is made from hydrophilic porous sintered resin material which comprises a lower part 16b at the side of the low temperature compartment 5 and an upper part 16a at the side of the cooled air path. The upper part 16a is smaller than the lower part 16b in a ratio of pores 16c (porosity) because the material which will form the upper part 16a is processed at a higher temperature during sintering than the material which will form the lower part 16b, and the upper part material gets denser to decrease the porosity. Because the cooling top plate 16 which is cooled to the lowest temperature among the temperatures in the chilled food case is made from the hydrophilic porous sintered resin material whose lower part has a moisture absorption and moisture retention function and whose upper part has a humidity adjusting function, the pores 16c in the lower part can absorb moisture to prevent dew

from being formed even if the evaporation of moisture is at a high level due to the presence of a great amount of stored food to create high humidity. If the moisture absorption and retention function is determined to meet the requirements needed for the presence of such great amount of stored food, moisture can be apparently absorbed too much when the amount of stored food is small. However, in such case, the discharge of moisture is decreased to keep the inside of the low temperature compartment 5 at high humidity because the pores 16c in the upper part which faces the cooled air path is processed under high temperature at the time of sintering. The hydrophilic porous sintered resin material functions to hold moisture in the pores. The part of the sintered resin material at the side of low temperature compartment which is liable to be at high humidity is required to be apt to hold moisture in order to prevent dew from falling onto the stored food. Conversely, if high humidity is not liable due to a small load, there is a possibility that the presence of the pores decreases the degree of closeness to dry the stored food. In order to cope with this problem, the part whose porosity is small is positioned at the cooled air path side to prevent moisture from being taken from the sintered resin material moisture held in it. In that manner, moisture is prevented from evaporating, and humidity is adjusted. If moisture is held at a small amount in the cooled air path side part, the humidity difference between the cooled air path side part and the cooled air is small, and moisture is not apt to evaporate. Conversely, if moisture is held at a large amount in the cooled air path side part, moisture is likely to evaporate (humidity adjusting function).

EMBODIMENT 6:

In the fifth embodiment, the cooling top plate 16 is produced in such manner that the sintering temperature of one side part is higher than that of the other side part at the time of sintering. In that manner, the forming of the pores 16c in the upper and lower parts is controlled. As shown in Figure 10, the cooling top plate can have the upper surface provided with a secondary processed surface 38 by means of hot stamping processing, painting or film-attaching to decrease the number of the pores 16c in the upper surface.

In addition, if there is a possibility that the amount of moisture absorption is locally great in the top plate 16 depending on temperature distribution, the processing area of the secondary processed surface 38 can be adjusted to increase the discharging amount of moisture locally.

In accordance with the fifth and sixth embodiments, the inside of the chilled food case can be kept at high humidity to restrain the stored food from being dried, thereby obtaining high quality preservation.

EMBODIMENT 7:

Referring now to Figures 11 and 12, there is shown a seventh embodiment of the present invention. Figures 11 and 12 correspond to Figures 1 and 2. In Figure 11, reference numeral 22 designates a defrosting heating element for the cooling top plate, which is provided on the undersurface of the partition wall 4. As shown in Figure 13, the top plate defrosting heating element 22 is connected in parallel with the evaporator defrosting heating element 21. Both heating elements are turned on by driving relay contacts 25 and 26, respectively, at certain intervals which are counted by timers 23 and 24. When defrosting completion temperature sensors 21a and 22a detect predetermined temperatures or above, the driving relay contacts 25 and 26 are turned off to finish defrosting the evaporator 18 and the top plate 16. In Figure 13, reference numeral 27 designates a power source.

In the seventh embodiment, defrosting the top plate and defrosting the evaporator are carried out independently. The present invention is also applicable to a case wherein the top plate defrosting heating element 22 is energized in synchronism with the evaporator defrosting heating element 21 as shown in Figure 14. Both heating elements 21 and 22 are turned on by the driving relay contact 25 for the evaporator defrosting heating element. When the defrosting completion temperature sensor 21a for the evaporator detects a predetermined temperature or above, both heating elements 21 and 22 are turned off by the driving relay contact 25.

The present invention is also applicable to a case wherein a bimetallic switch 28 which breaks contacts when the temperature rises to a certain value is provided at a location near to the top plate 16 to turn off the top plate defrosting heating element 22 when the temperature of the top plate 16 or in the closed low temperature compartment 5 rises to the certain value. In that case, the defrosting heating element 22 is arranged in a crowded form in particular at a location in close proximity to an outlet from the shunt supply passage 15 into the cooled air path 17, that location being likely to be iced because that location has the lowest temperature. Such arrangement can equally defrost without trouble.

In accordance with the seventh embodiment, even if the cooling top plate is iced, the ice formed can be melted by the heating element which is arranged in the cooling air path above the top plate.

EMBODIMENT 8:

An eighth embodiment of the present invention will be explained referring to Figures 11 and 16. In the eighth embodiment, the cooling top plate 16 which is made of the porous material contains at least 2% of a deodorizing catalyst, and at least of 2% of antibacterial agent such as TBZ (2-(4-thiazolyl)-benzimidazole) by weight ratio to the porous material, the deodorizing catalyst being mainly composed of lanthanum oxide, zirconium phosphate and titanium oxide. According to such arrangement, the deodorizing catalyst and the antibacterial agent which are contained in the cooling top plate 16 exert effect on the cooled air which is passing through the cooled air path 17. Heating element 22 is arranged on the under surface of the partition wall 4 to face the top plate 16, thereby promoting the effect on the cooled air by the deodorizing catalyst and the antibacterial agent. The heating element 22 has such arrangement that it is periodically energized from a power source 24 by a timer 23 as shown in Figure 16. In accordance with the arrangement of the eighth embodiment, the cooled air is directed through the shunt supply passage 15 to the cooling top plate 16 which is made of the porous material and contains the deodorizing catalyst and the antibacterial agent. The cooled air flows along the upper surface of the top plate 16, passes along the outer surfaces of the chilled food case 7 and through the cooled air passage 19 on the outer bottom surface of the chilled food case 7, and is discharged into the refrigerating compartment 3. This arrangement can prevent the closed low temperature compartment 5 from having a fungus or an odor in it.

The decomposition reaction due to the deodorizing catalyst in the top plate 16 is promoted, as shown in Figure 17, by the heating element 22 which is arranged to face the top plate 16. On the other hand, although there is a possibility that the closed low temperature compartment 5 gets musty due to high humidity, such possibility can be eliminated by the antibacterial agent which is contained in the top plate 16. In addition, periodical energization to the heating element 22 by the timer 23 prevents the temperatures in the chilled food case 7 and in the closed low temperature compartment 5 from rising.

EMBODIMENT 9:

A ninth embodiment of the present invention will be explained referring to Figure 18. In the ninth embodiment, the opening and closing control of the damper thermostat 14, the on and off control of the fan 20, the on and off control of the evaporator defrosting heating element 21, and the on and off control of the defrosting heating element 22 for the cooling top plate 16 are carried out by a microcomputer 39. The moisture which has been put as dew on the cooling top plate 16 is cooled by the cooled air passing through the cooled air path 17 to be deposited as frost. In order to cope with this problem, the microcomputer 39 controls the energization to the top plate defrosting heating element 22 at certain intervals to carry out defrosting. At the same time that the defrosting starts, the microcomputer controls the damper thermostat 14 to forcibly close the damper, thereby preventing the cooled air from passing through the cooled air path 17 during defrosting. As a result, the heat generated from the cooling top plate defrosting heating element 22 is effectively transferred to the cooling top plate 16 without having the heat taken off by the cooled air. After the defrosting has been completed, the damper thermostat 14 is released from the forcibly closing instruction, and returns to a normal opening and closing control. A timing chart and a flowchart which indicate such controls are shown in Figures 19 and 20, respectively. In Figure 19, the damper thermostat 14 is closed based on an instruction from the microcomputer 39 at a time t_1, and energizing the defrosting heat element 22 for the cooling top plate 16 simultaneously starts. Effective defrosting is carried out in such manner that the cooled air is prevented from passing through the cooled air path 17 during defrosting. At a time t_2 when defrosting has been completed, the microcomputer 39 issues a damper opening instruction to the damper thermostat 14 to return to the normal opening and closing control. In Figure 20, it is determined at Step 60 whether defrosting starting conditions are met or not. If affirmative, the cooling top plate heating element 22 is turned on at next Step 61. The damper thermostat 14 forcibly closes the damper to carry out defrosting at Step 62. At next Step 63, it is determined whether defrosting terminating conditions are met or not. If affirmative, the cooling top plate heating element 22 is turned off at Step 64, and the damper thermostat 14 is returned to a normal control at Step 65.

EMBODIMENT 10:

A tenth embodiment of the present invention will be explained referring to Figure 21. In Figure 21, reference numeral 40 designates a temperature sensor which detects the temperature of the cooling top plate defrosting heating element 22, and whose output is transmitted to the microcomputer 39. Although in the ninth embodiment the damper thermostat 14 is controlled to forcibly close the damper while the defrosting heating element 22 is being energized, in the tenth embodiment the

microcomputer 39 controls the damper thermostat 14 to forcibly open the damper to lower the temperature of the defrosting heating element 22 at the time when the temperature of the defrosting heating element 22 has achieved T_{max}. The microcomputer 39 controls the damper thermostat 14 to forcibly close the damper again at the time when the temperature of the defrosting heating element 22 has lowered to T_{min}. Such controls allow the temperature of the defrosting heating element 22 to be controlled in the range of $\Delta T = T_{max} - T_{min}$, preventing the cooling top plate 16 from being overheated due to unnecessary heating by the defrosting heating element 22. In that manner, the temperature of the food in the chilled food case 7 can be prevented from rising to improve preservability of the stored food. A timing chart of such controls and a flowchart thereof are shown in Figures 22 and 23, respectively. In Figure 23, it is determined at Step 70 whether defrosting starting conditions are met or not. If affirmative, the cooling top plate heating element 22 is turned on and the damper thermostat 14 forcibly closes the damper at Step 71. At Step 72, it is determined whether defrosting termination conditions are met or not. If negative, the temperature of the cooling top plate 16 is compared to a preset acceptable maximum temperature T_{max} at Step 73. If the top plate temperature is not less than T_{max}, the damper thermostat 14 forcibly opens the damper to lower the temperature of the cooling top plate 16 at Step 74. At Step 75, it is determined whether defrosting terminating conditions are met or not. If negative, the temperature of the cooling top plate 16 is compared to a preset acceptable minimum temperature T_{min} at Step 78. If the top plate temperature is not higher than T_{min}, the damper thermostat forcibly closes the damper at Step 79.

EMBODIMENT 11:

An eleventh embodiment of the present invention will be described referring to Figures 24 through 28. In Figure 24, reference numeral 41 designates a control unit which controls the refrigerator. Reference numeral 42 designates a console panel through which a user can set a desired temperature for the refrigerating compartment 3. In Figure 25, there is shown a schematic block diagram of the control unit. In Figure 25, reference numeral 39 designates a microcomputer which comprises a CPU 39a, a RAM 39b, a ROM 39c, an input unit 39d, and an output unit 39e. Reference numeral 43 designates a thermistor which detects the temperature in the frozen food compartment 2. Reference numeral 44 designates a thermistor which detects the temperature in the refrigerating compartment 3. Reference numeral 45 designates a driving circuit which is used to activate various actuators based on output signals from the microcomputer 39. Reference numeral 46 designates photo-TRIAC (light receiving side). Reference numeral 47 designates a compressor. Reference numeral 48 designates a power source. Reference numeral 49 designates a frequency detector for the power source 48.

The operation of the eleventh embodiment will be explained referring to a flowchart for heating control shown in Figure 28. At Step 107 it is determined whether the heating element 22 is energized at 100% of power input for defrosting or not. Then the desired temperature for the frozen food compartment 2 which has been set through the console panel 42 is compared to the temperature which is detected by the thermistor 43 for detecting the actual temperature in the frozen food compartment 2 (Step 100). If the actual temperature in the frozen food compartment 2 is higher than the desired temperature, the compressor 47 and the fan 20 are driven (Step 101). As a result, a refrigerant is forwarded to the evaporator 18, and the cooled air which has been produced by the evaporator 18 is carried by the fan 20 to be blown off into the frozen food compartment 2, thereby cooling it. A part of the cooled air is transferred to the cooled air outlet 13a through the supply passage 13 leading to the refrigerating compartment 3. The electric damper 14 controls the inflow amount of the cooled air from the cooled air outlet 13a to cool the inside of the refrigerating compartment 3 to a desired temperature (e.g. 3°C), comparing the desired temperature for the refrigerating compartment with the temperature which is detected by the thermistor 44 for detecting the actual temperature in the refrigerating compartment 3 (Steps 102, 103 and 104). Another part of the cooled air passes through the shunt supply passage 15, and flows along the upper surface of the cooling top plate 16 which is made from the porous material. Then that part of the cooled air is discharged into the refrigerating compartment 3 through the cooled air passage 19 around the outer surfaces and the outer bottom surface of the chilled food case 7. The arrangement wherein the surface of the cooling top plate which the supplied cooled air is first given to has the lowest temperature among the temperatures in the chilled food case 7 prevents the temperatures of the inner bottom surface with stored food put thereon and the inner peripheral surfaces of the chilled food case 7 from lowering to excessive levels, thereby avoiding the state wherein the food stored in the chilled food case 7 is frozen. Although the arrangement wherein the cooling top plate 18 which is subjected to the lowest temperature is made from the porous material capable of holding moisture can hold the moisture evaporated

from the stored food in the top plate 16, there is a possibility that the surface of the cooling top plate 16 is iced due to the lowest temperature. In order to cope with this problem, there is provided means for detecting icing. Specifically, the time period T in which the compressor 47 is being driven is measured (Step 105). It is determined whether the measured time period T has been beyond a predetermined value or not (Step 106). If affirmative, the program proceeds to Step 108 where it is determined whether the temperature detected by the thermistor 40 for detecting a temperature near to the heating element 22 is not higher than A or not. If affirmative, the heating element 22 is energized under the energizing conditions as shown in Figure 27 (Step 112) to cause the moisture held in the cooling top plate 16 to evaporate in the cooling air path 17, thereby renewing the top plate 16. Turning off the heating element 22 is done when the temperature detected by the thermistor 40 has achieved A or above (Steps 107, 108 and 114). Next, operations other than defrosting will be explained. Explanation of the operations common to the defrosting operation will be omitted for the sake of simplicity. The heating element 22 is energized under the energizing conditions shown in Figures 27 and 28, depending on the desired temperature for refrigerating compartment 3 and the state of the electric damper 14, thereby keeping energizing in the chilled food case 7 at constant (Steps 109, 110 and 111).

Although the explanation of the eleventh embodiment has been made for the case wherein phase control is carried out by the photo-TRIAC 46 to adjust the heat generation of the heating element 22, the present invention is also applicable to a case wherein the heat generation is adjusted for every time period in e.g. such manner that the heating element 22 is energized for 1 minute and is turned off for 4 minutes. In that case, even an on off device such as relay can be used to offer advantage similar to the eleventh embodiment.

Claims

1. A refrigerator with a frozen food compartment wherein cooled air which is produced by an evaporator (18) is forcibly carried to a refrigerating compartment (3) and other compartments (2, 5) by a fan (20); characterized in that it comprises:

   a low temperature compartment (5) which is arranged in the refrigerating compartment (3), and which has a front portion opened;

   a chilled food case (7) which is housed in the low temperature compartment (5) to be slidable forward and backward therein, and which has a front portion and an upper portion opened;

   a common cover (8) which can close and disclose the front portions of the low temperature compartment (5) and the chilled food case (7);

   a cooling top plate (16) for covering the upper opened portion of the chilled food case (7);

   a cooled air path (17) which is formed between the top plate (16) and the low temperature compartment (5); and

   a supply passage (13) which directs a part of the cooled air produced by the evaporator (18) to the cooled air path (17).

2. A refrigerator according to Claim 1, characterized in that it further comprises a cooled air passage (19) which communicates with the cooled air path (17), which is formed on an outer peripheral surface of the chilled food case (7), and which opens on the refrigerating compartment (3).

3. A refrigerator according to Claim 1, characterized in that it further comprises a cooled air return passage (37) which returns the cooled air to the evaporator (18).

4. A refrigerator according to Claim 1, characterized in that it further comprises:

   a fixing frame for the chilled food case, including an upper frame (30) and a rear projecting frame (33);

   the upper frame (30) covering the upper opened portion of the chilled food case (7) and having the top plate (16) put thereon;

   the rear projecting frame (33) formed with the upper frame (30) through a hinge portion (31) in one-piece, forming a part of the cooled air passage (19), and having a rear end surface abutted against a rear inner wall of the low temperature compartment (5) to be fixed.

5. A refrigerator according to Claim 1, characterized in that the cooling top plate (16) is arranged above the chilled food case (7), and is engaged with the low temperature compartment (5) through a surrounding frame (35) so as to be detachable downward, the surround frame (35) being arranged around the cooling top plate (16).

6. A refrigerator according to Claim 1, characterized in that the cooling top plate (16) is made of a porous material.

7. A refrigerator according to Claim 6, characterized in that the cooling top plate (16) com-

prises a hydrophilic porous material (16a) having a humidity adjusting function at the side of the cooled air path (17), and a hydrophilic porous material (16b) having a water absorption and water retention function at the side of the chilled food case (17).

8. A refrigerator according to Claim 6, characterized in that the cooling top plate (16) comprises a hydrophilic porous material (16a) having a small porosity at the side of the cooled air path (17), and a hydrophilic porous material (16b) having a great porosity at the side of the chilled food case (7).

9. A refrigerator according to Claim 1, characterized in that the cooling top plate (16) contains a deodorizing catalyst and an antibacterial agent.

10. A refrigerator according to Claim 1, characterized in that the cooled path (17) above the cooling top plate (16) includes a heating element (22).

11. A refrigerator according to Claim 10, characterized in that it further comprises control means (39) which carries out such control that the supply passage (13) is shut while energizing the heating element (22) at the time of defrosting the cooling top plate (16).

12. A refrigerator according to Claim 11, characterized in that the heating element (22) is provided with a temperature sensor (40), and has control means (28, 23, 39) which carries out such control that the temperature of the heating element (22) is kept at constant during energization.

13. A refrigerator according to Claim 10, characterized in that it further comprises a heating element (22) for defrosting the cooling top plate (16) and controlling the temperature in the chilled food case (7), and means (46) for adjusting the heat generation from the heating element (22).

14. A refrigerator according to Claim 13, characterized in that the heat generation adjusting means (46) adjusts the heat generation, depending on the time period in which a compressor (47) is being driven.

15. A refrigerator substantially as described with reference to Figures 1 to 3, Figures 4 to 6, Figures 7 and 8, Figure 9, Figure 10, Figures 11 to 15, Figures 16 and 17, Figures 18 to 20, Figures 21 to 23, or Figures 24 to 28 of the accompanying drawings.

FIGURE I

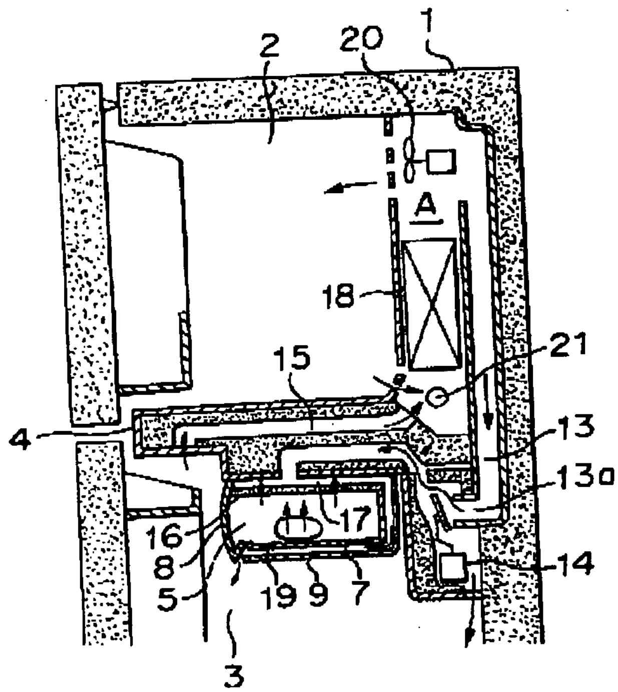


FIGURE 2

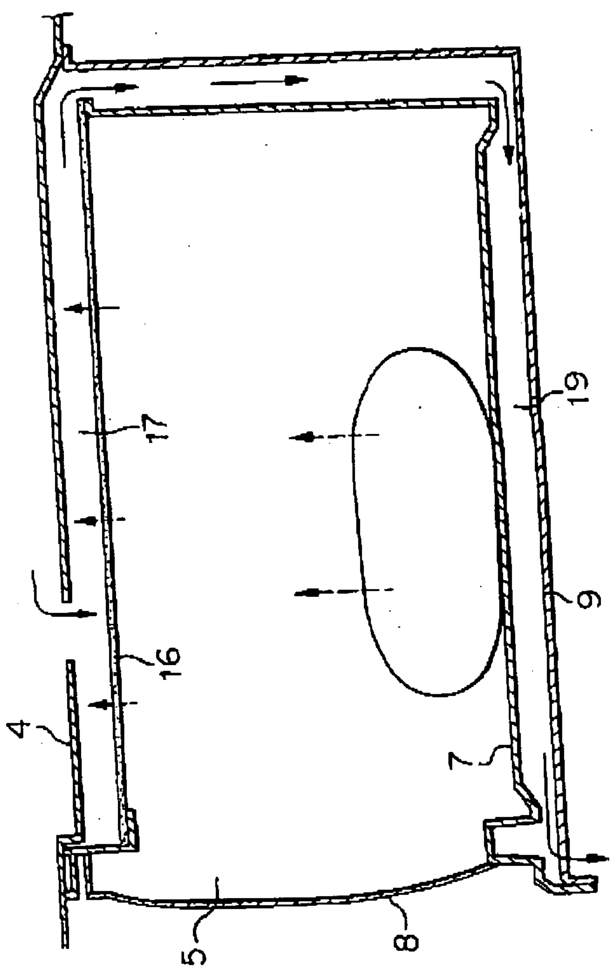


FIGURE 3

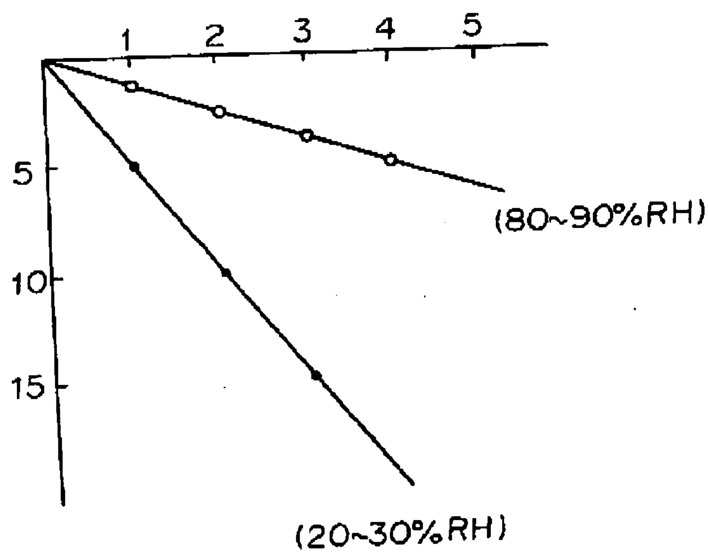


FIGURE 4

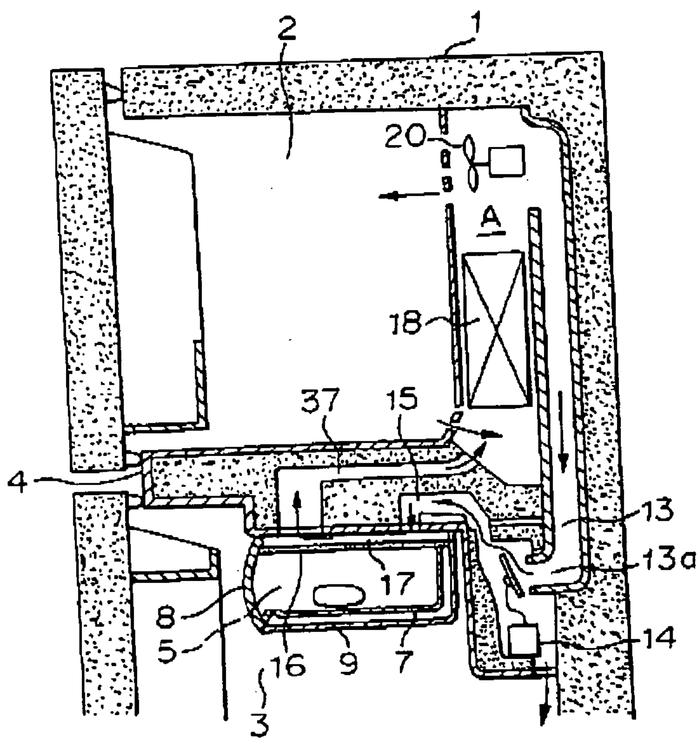


FIGURE 6

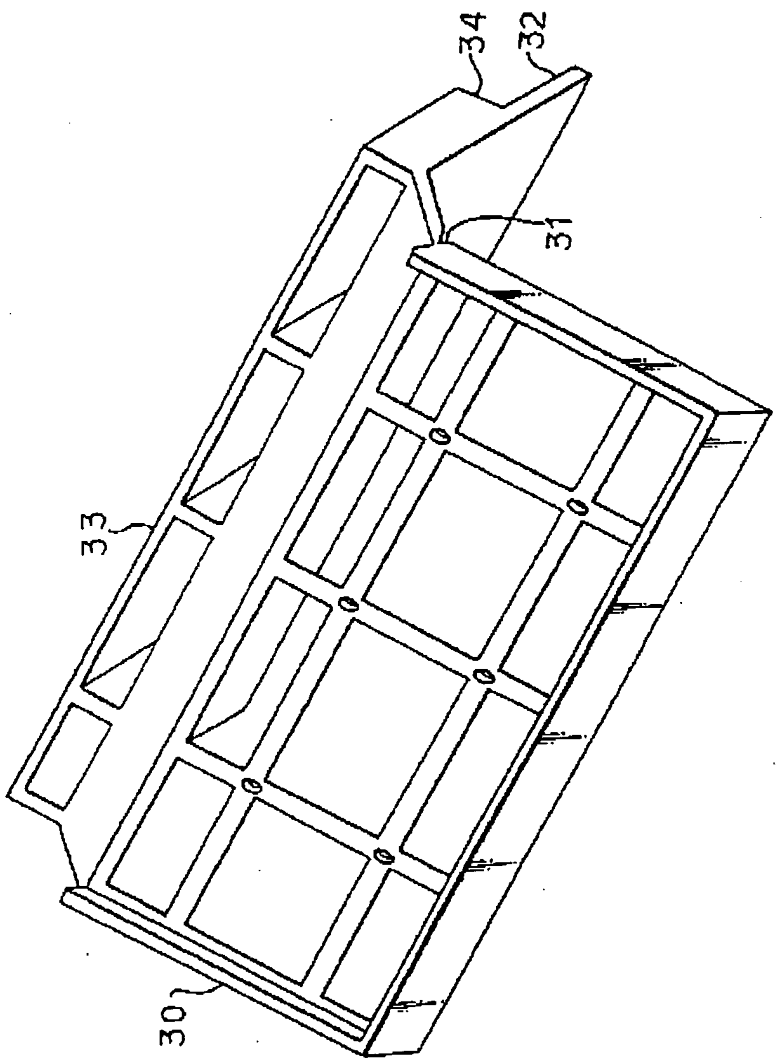


FIGURE 7

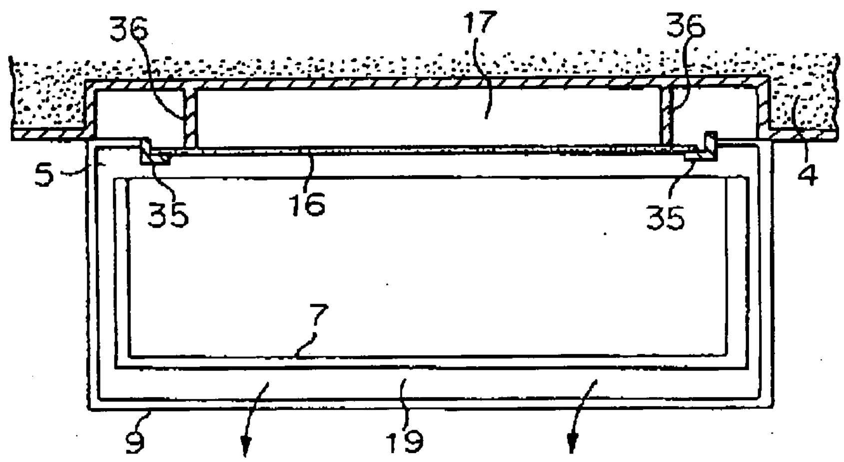


FIGURE 8

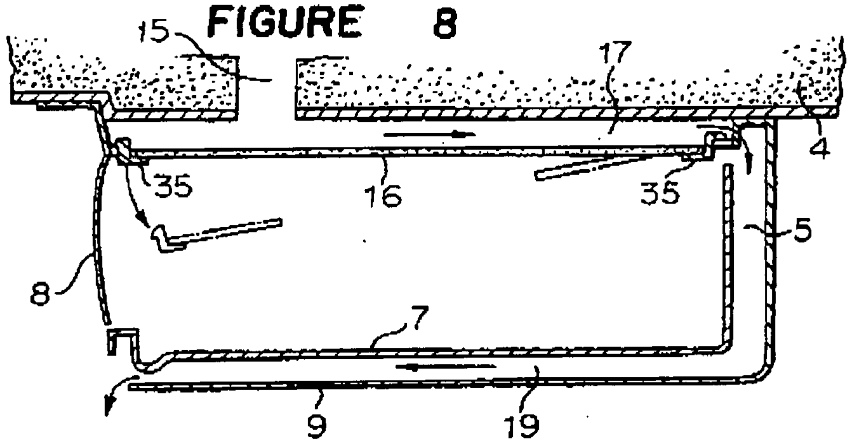


FIGURE 9

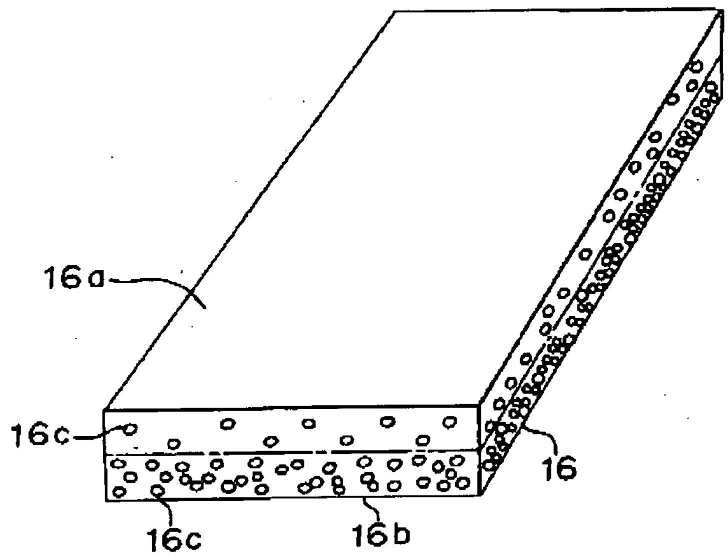


FIGURE 10

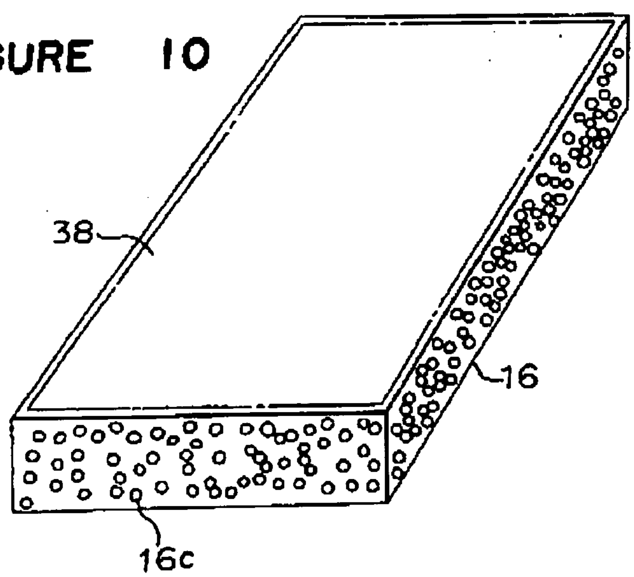


FIGURE 11

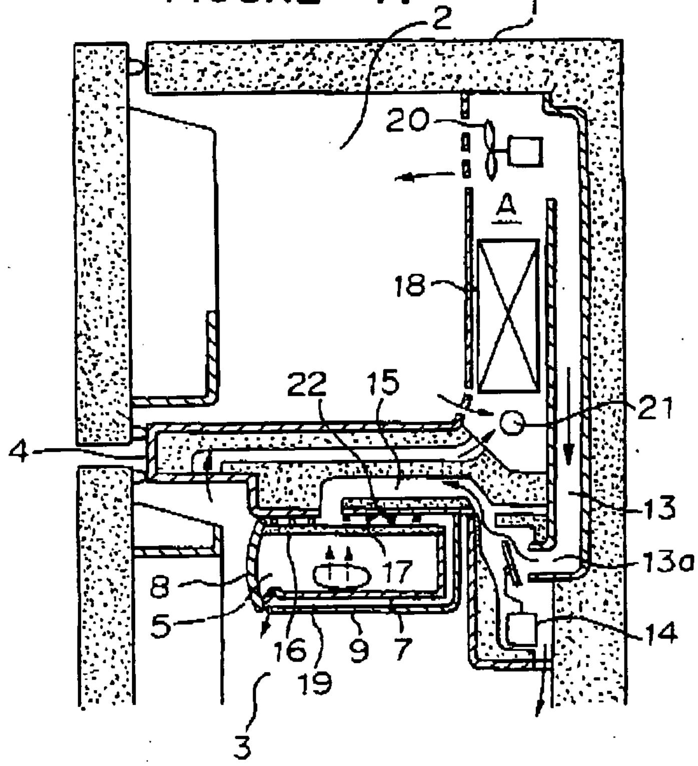
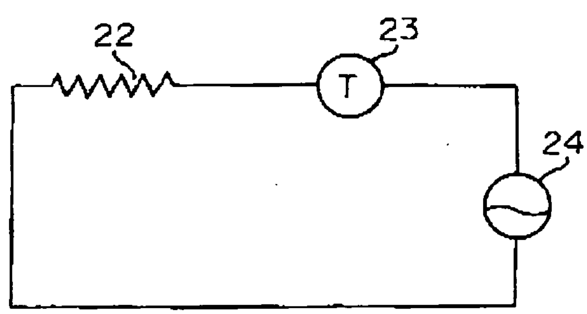


FIGURE 16



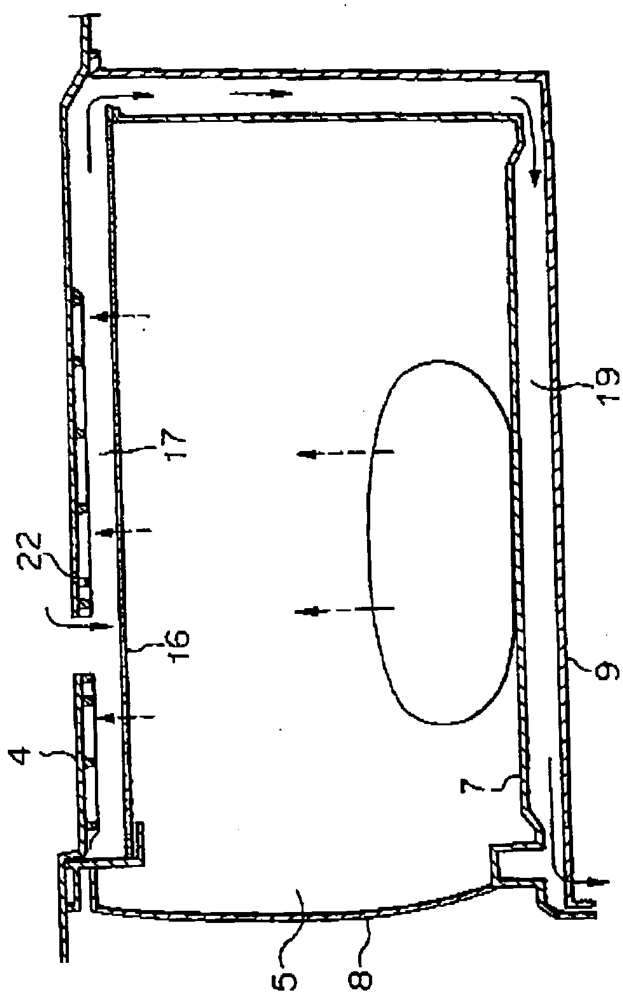


FIGURE 12

FIGURE 13

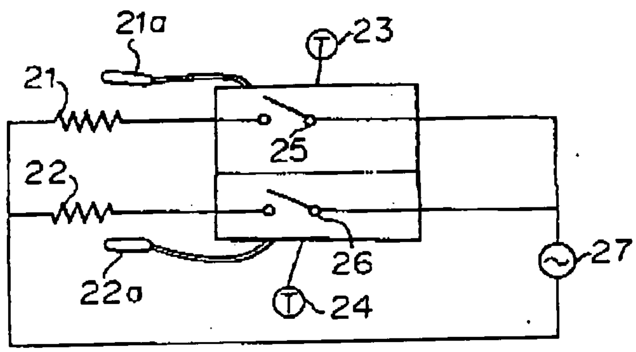


FIGURE 14

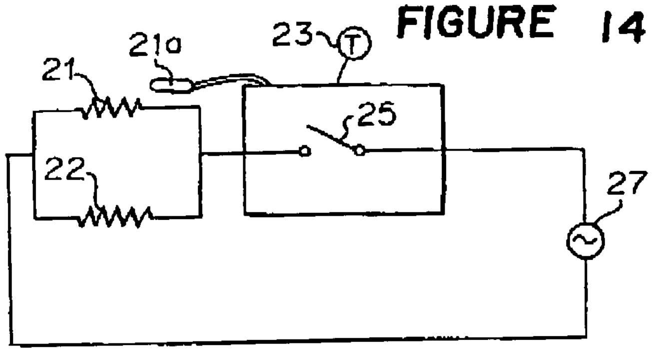


FIGURE 15

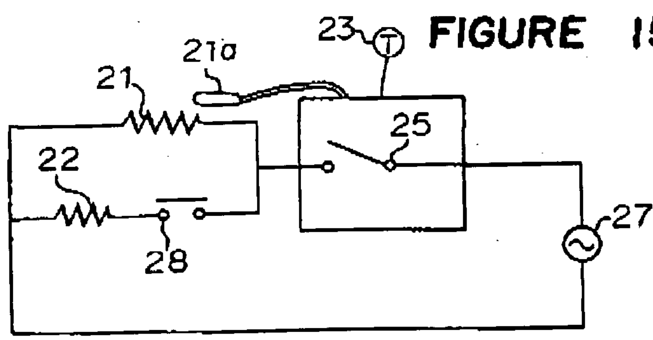


FIGURE 17

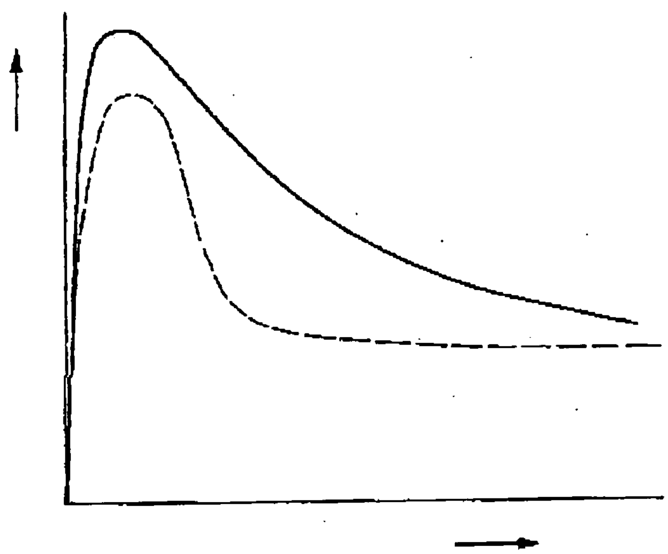


FIGURE 5

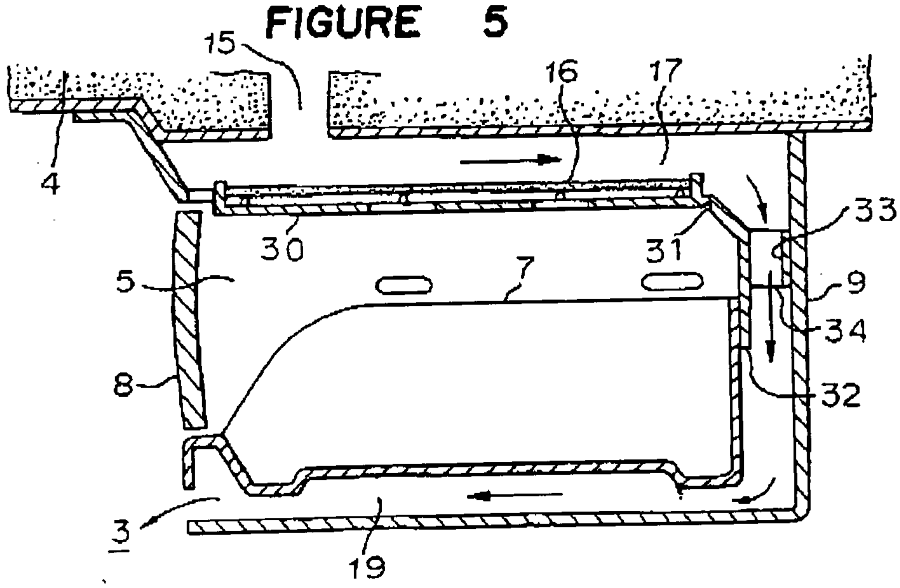


FIGURE 18

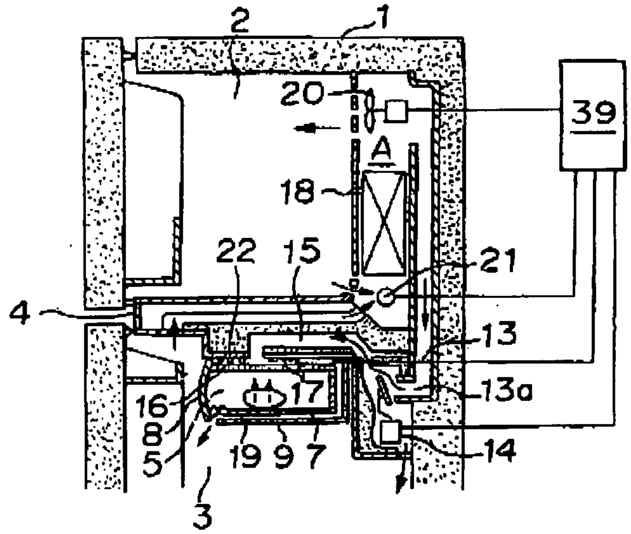


FIGURE 19

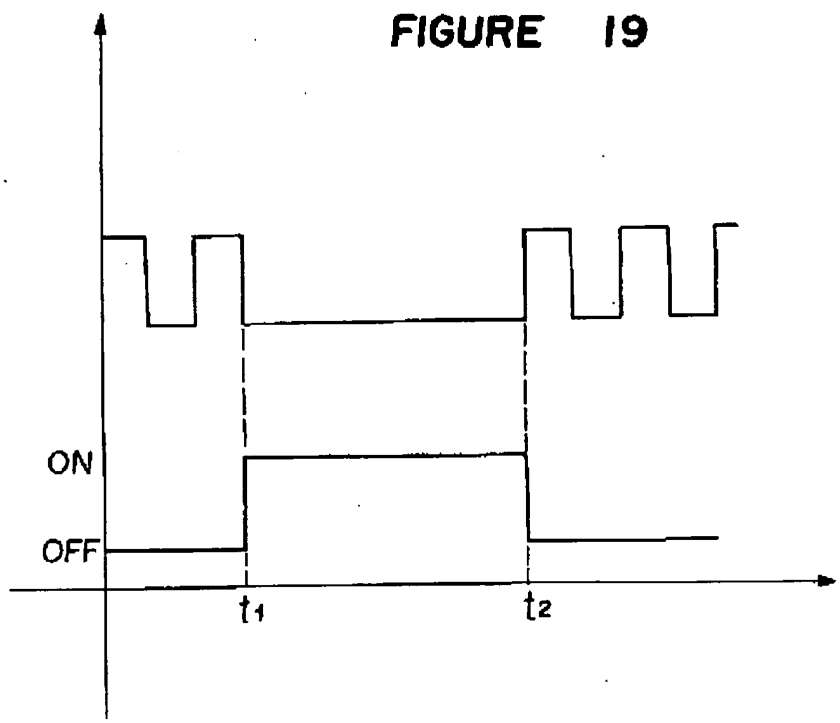


FIGURE 20

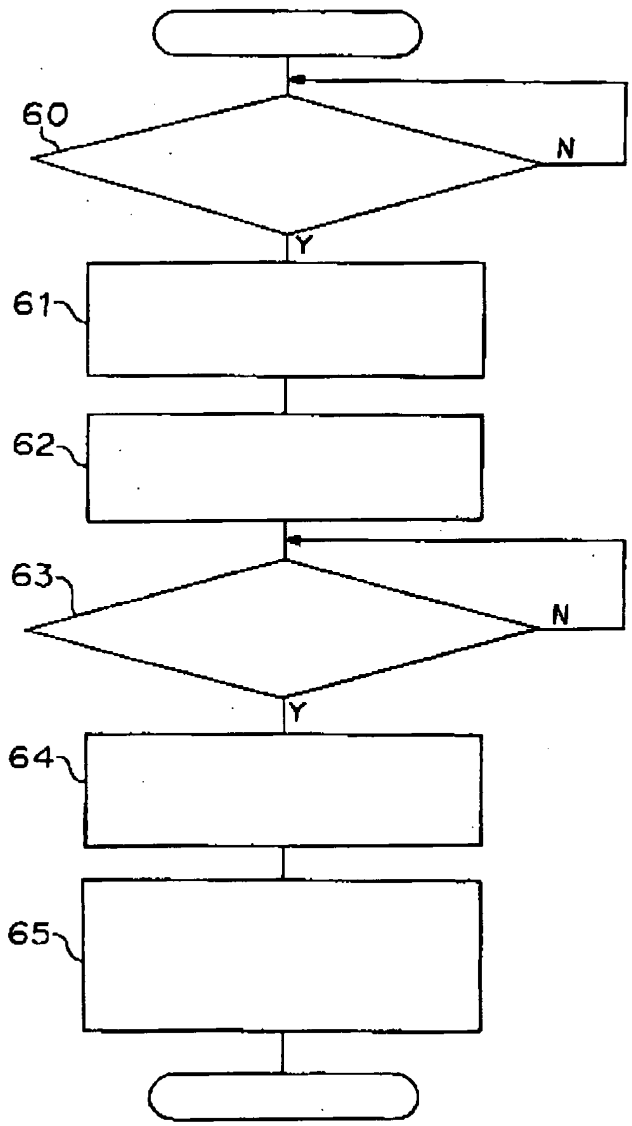


FIGURE 21

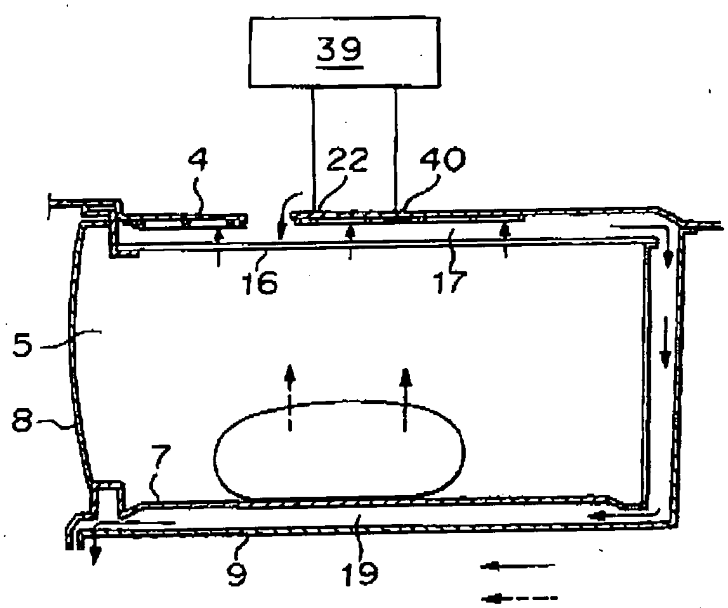


FIGURE 22

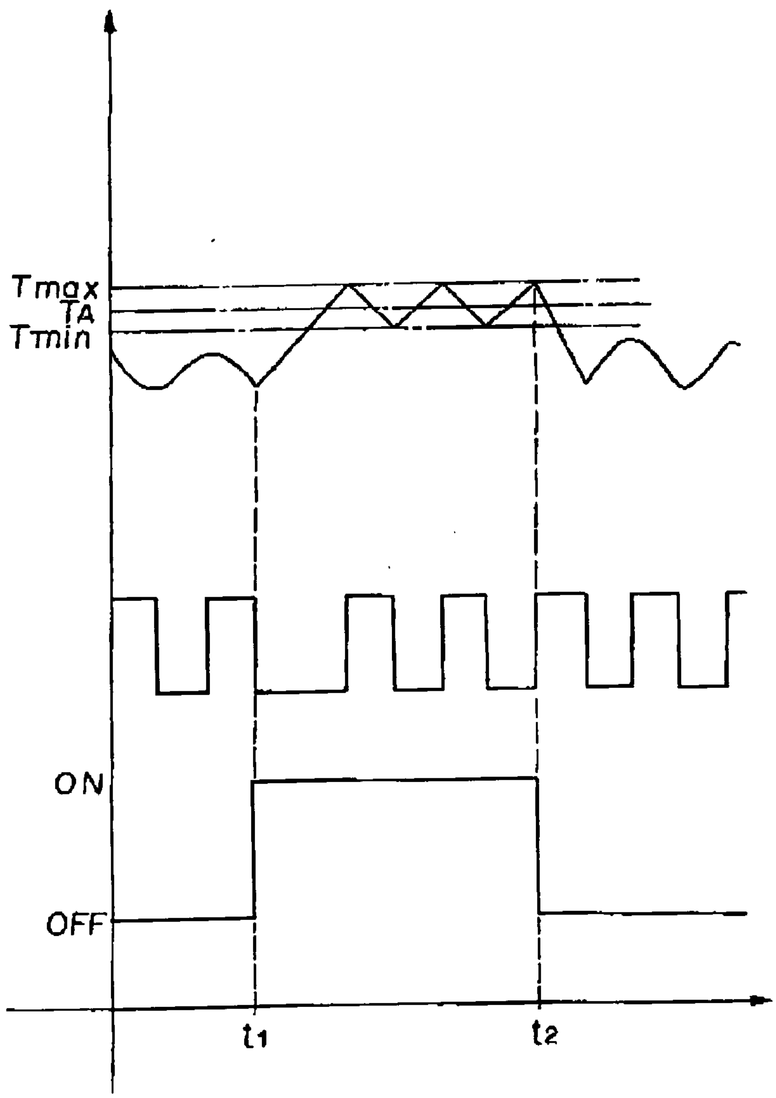


FIGURE 23

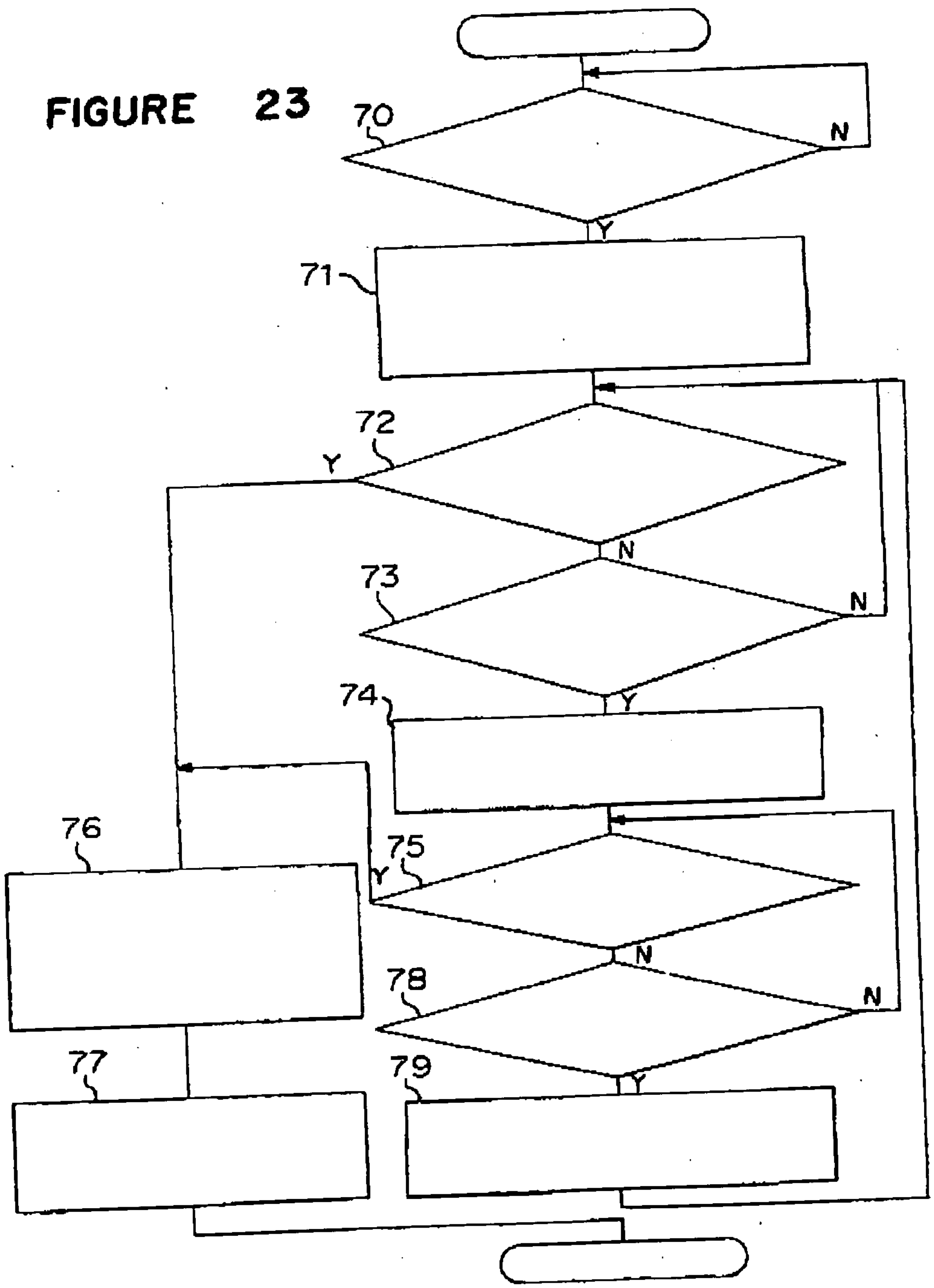


FIGURE 24

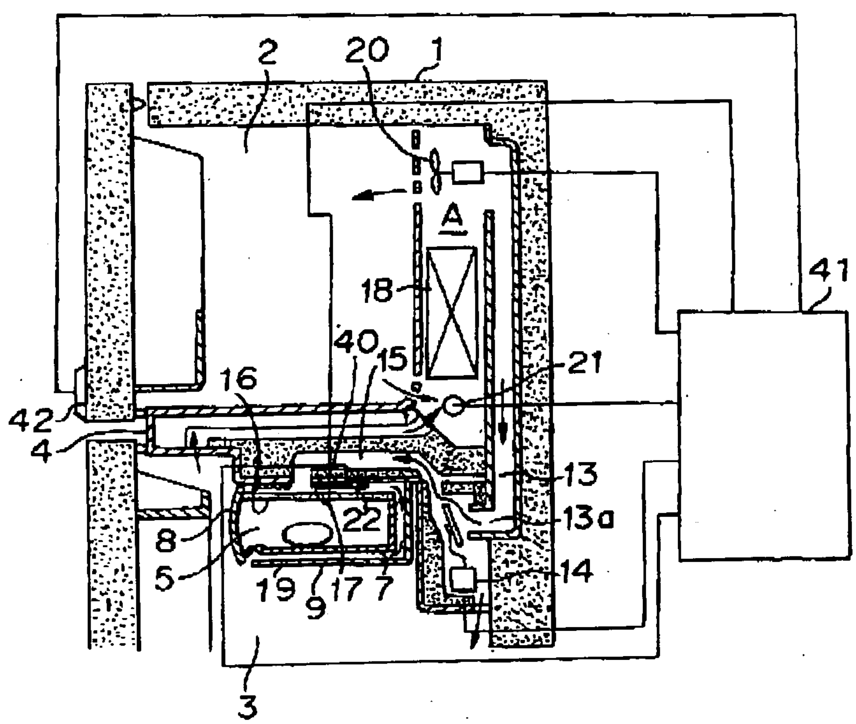
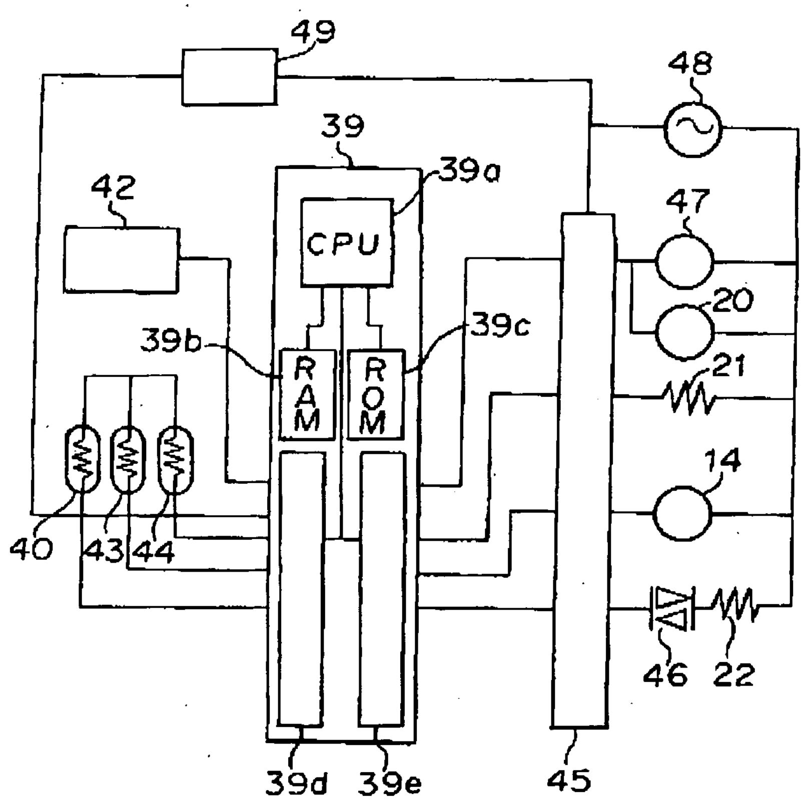


FIGURE 25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39a
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CPU
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39c
RAM
ROM
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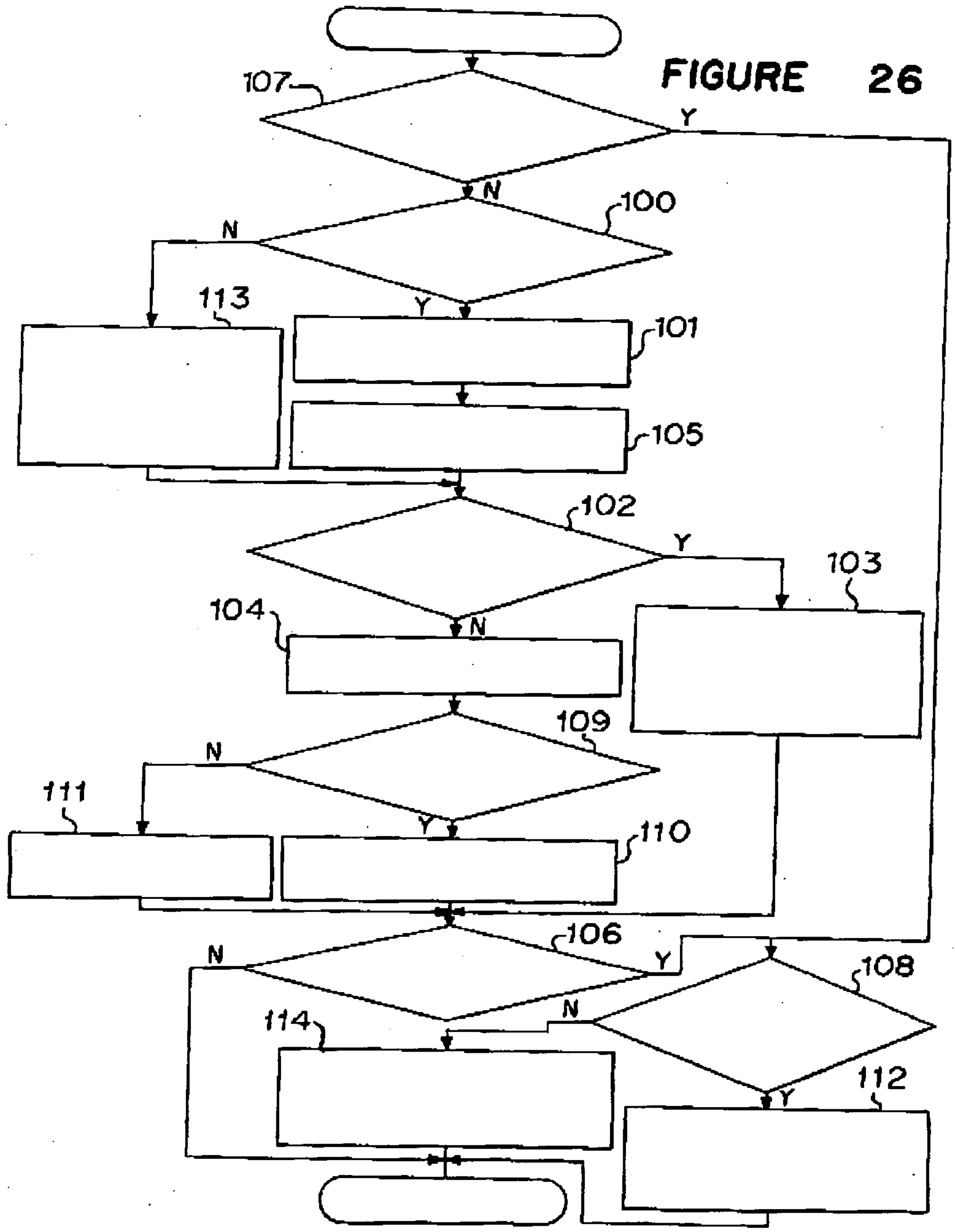
22
39d
39e
45

FIGURE 26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Y
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FIGURE 27

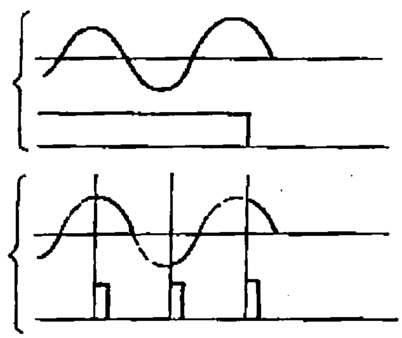

FIGURE 28

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FIGURE 29

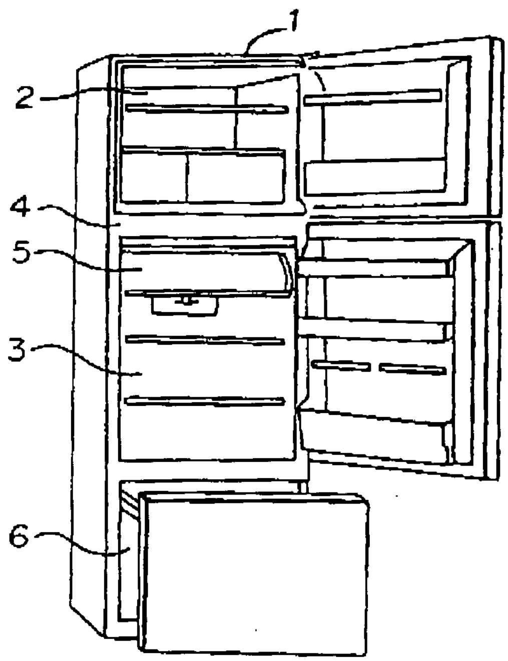

FIGURE 30